FACTSHEET FOR SOUTHWEST PARTNERSHIP FIELD VALIDATION TEST

Partnership Name	Southwest Regional Partnership on Carbon Sequestration		
Contacts: DOE/NETL Project Mgr.	Name William O'Dowd	Organization NETL	E-Mail William.ODowd@NETL.DOE.GOV 1-412-386-4778
Principal Investigator	Brian McPherson	SWP	brian@nmt.edu 1-801-581-5634
Field Test Information: Field Test Name	Southwest Jurassic/Triassic Deep Saline Sequestration		
Test Location	La Veta, Colorado		
Amount and Source of CO_2	Tons 2.9 Million tons	Source 400,000 tons from CBM operation; remainder from Farnham Dome (natural source)	
Field Test Partners (Primary Sponsors)	Savoy Energy, LLC		
	Pure Petroleum, LLC		
	Blue Source, LLC Pacificorp Southern California Edison		

Summary of Field Test Site and Operations:

SWP plans to accomplish two sequestration deployments. The first stage deployment will occur at the La Veta Field in the Raton Basin in Colorado. This test will follow an injection schedule over 4 years, leading up to 900,000 tonnes (1,000,000 U.S. tons) of CO_2 per year. The second stage will occur in Wyoming's Green River Basin and will total 90,000 tonnes (100,000 U.S. tons) of CO_2 injected in a one year period. The target formation is the Entrada Formation of Jurassic age in both the Raton Basin in Colorado and the Green River Basin in Wyoming. Should the Jurassic Entrada have insufficient injectivity, the Triassic and Permian formations below the Jurassic are also great candidates for sequestration. By carrying out two tests in the same formation in different states, portability of science and engineering results may be evaluated.

Injection Site Description

Colorado Site: The La Veta field injection site is located in the northwest comer of the Raton basin, 20 miles west of Walsenburg, in Huerfano County in south-central Colorado. This 6000 acre field was discovered in 1997 and is under development. Because La Veta is an active gas field, the state of access is commercial with no physical impediments to impact the project. It is not located on wetland or a sole-source aquifer where injection or monitoring wells will penetrate.

Wyoming Site: SWP suggests that the best location for the Green River Basin CO_2 injection deployment is the Rock Springs uplift, the site of the Jim Bridger power plant, owned and operated by Pacificorp Energy. The Jurassic Entrada is capped by thick confining layers, and the injection site is at its most shallow depth underneath the Bridger power plant (~7,000 feet depth). The sites near this locale that SWP is investigating are owned by the Bureau of Land Management, with no physical impediments to impact the project. They are not located on wetland or sole-source aquifers where injection or monitoring wells will penetrate. Injection here will not begin until late 2009, providing some time to identify an optimum injection well location in the area.

Description of Geology

The target formation is the Entrada Formation of Jurassic age in both the Raton Basin in Colorado and the Green River Basin in Wyoming. The Entrada Formation is a deep saline unit present throughout the Southwest Partnership region, as well as in many states outside the region. The formation contains mudstones, claystones, and siltstones, as well as lenticular sandstone beds, limestone, and conglomerate. Below the Entrada are more excellent candidate reservoirs of Triassic and Permian age. In all cases, the seal is the Morrison Formation, a thick (400 feet) shale/gypsum/siltstone of Jurassic age, also regionally present throughout the Southwest Partnership states. At both sites, the unit lies within a true "stacked" system (Figure 1)—above the Entrada/Morrison combination lies the Dakota formation, a Cretaceous-aged sandstone similar to the Entrada and capped by the Pierre/Mancos shale, a very thick (1,500 feet to 5,000 feet) shale unit. The SWP has gathered porosity, permeability, mechanical, compositional, and geophysical data associated with these target reservoirs and seals.

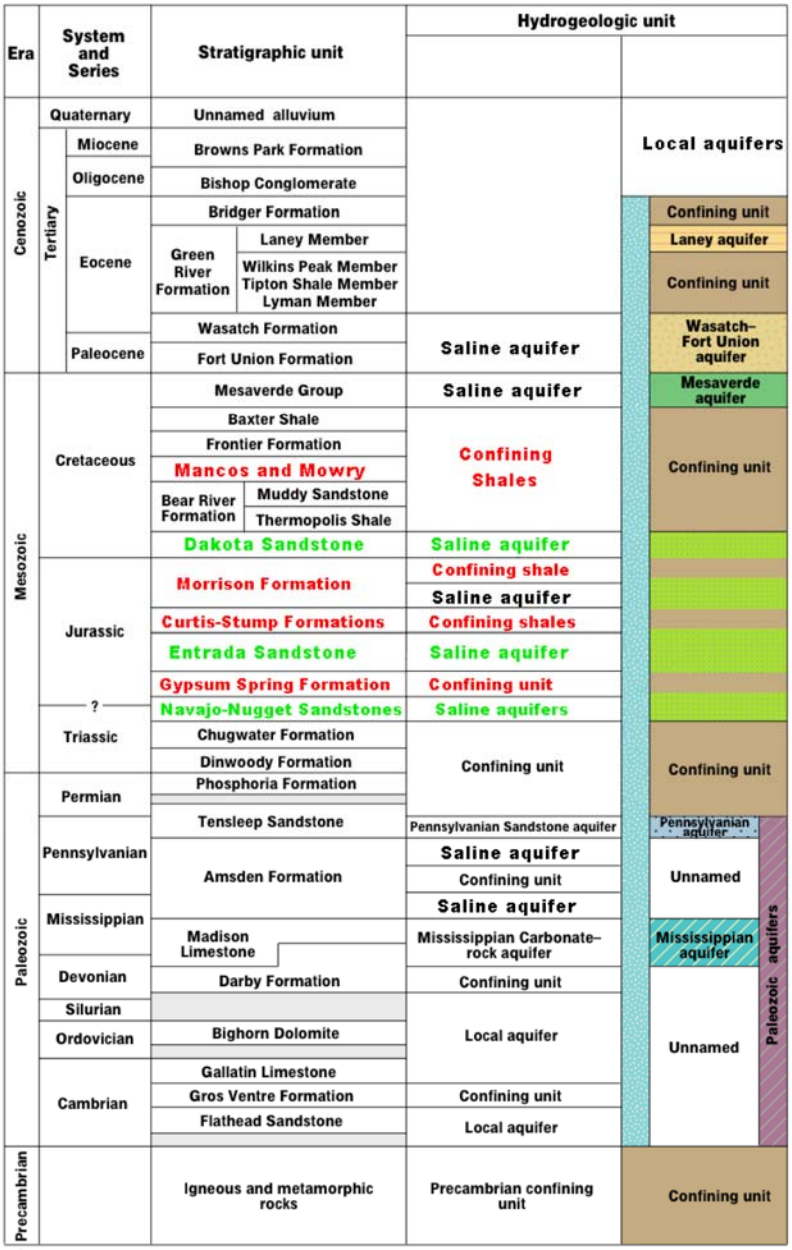

Figure 1. Generalized stratigraphic column for the SWP region of interest.

The Raton Basin was formed during the Laramide orogeny as tectonic activity caused uplift of the Sangre de Cristo Mountains. This created numerous folds and faults throughout the basin. The western margin of the basin is highly deformed, with large numbers of faults and fractures. Also, Tertiary volcanism led to additional faulting across the western side of the Sangre de Cristo Mountains. At the western margin near the site, location fractures are directly linked to the thrust fold along the western edge of the basin. As a whole, the northern section of the Raton Basin is more stable and less faulted than the southern portions. The Deployment Phase well location has very few significant faults in the vicinity; however, the proximity of the western basin edge and the compressional faulting at the Sangre de Cristo Mountain thrust front create a need for careful identification of faults and fractures near the injection well.

Source of CO_2

Colorado site: For the Raton Basin deployment site, the source of CO_2 is a natural gas processing plant, located in the La Veta field. This plant uses a non-amine membrane process for separating CO_2 and vents over 360,000 tonnes (400,000 U.S. tons) per year to the atmosphere. Production at La Veta is slated to increase, which will double the amount of CO_2 to over 730,000 tonnes (800,000 U.S. tons) per year in the near future. A short pipeline will need to be added to facilitate injection of captured CO_2 into the Entrada underneath the gas-processing plant.

The CO_2 captured will be 97% pure, with the remainder nitrogen (air). Should this source be insufficient for the tests, the CO_2 will be drawn from the Sheep Mountain source and pipeline, 16 miles away from the injection site.

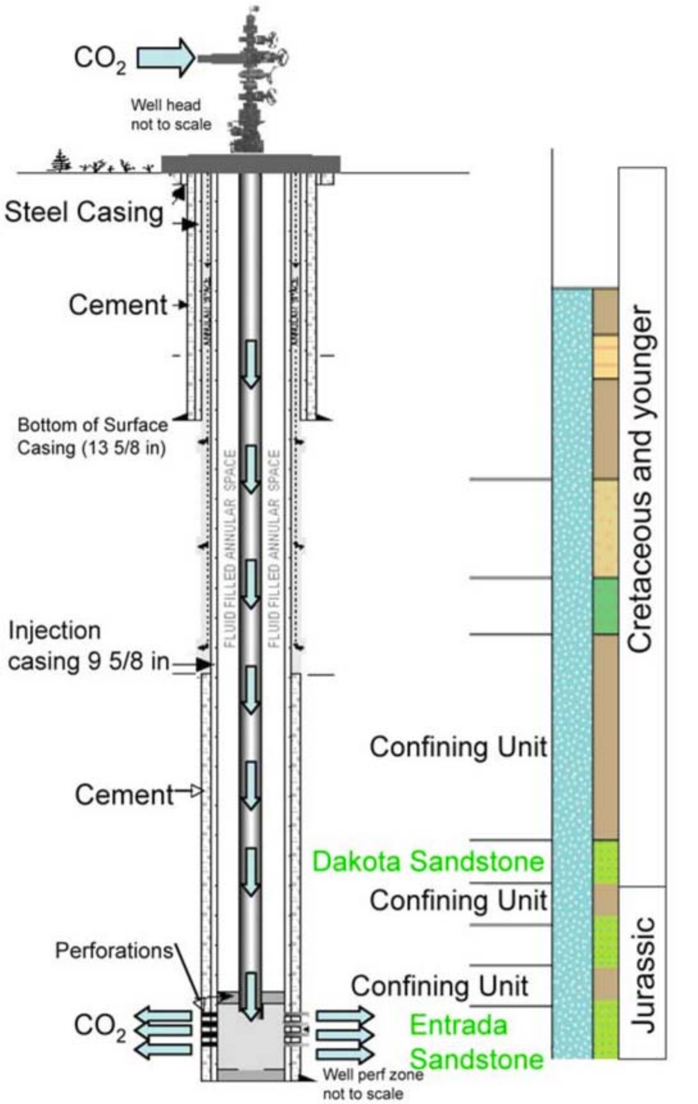

Figure 2. Schematic of injection well design.

Wyoming site: For the Green River basin test, the actual injection site will not be selected until the Deployment Phase begins, with injection slated to begin in 2009. However, the SWP anticipates the best location for injection to be coincident with the location of the Jim Bridger Power Plant in Rock Springs, Wyoming, a power plant owned and operated by Pacificorp, a SWP partner. Accordingly, the most promising source of CO_2 for this deployment is ExxonMobil's Shute Creek Facility (La Barge plant in southern Wyoming), a source of anthropogenic CO_2. According to the Wyoming Pipeline Authority, Exxon's Shute Creek facility serves as the supply source for all CO_2 enhanced oil recovery projects within Wyoming. A 24-inch CO_2 pipeline runs from the Shute Creek Facility to Rock Springs. The CO_2 at Shute Creek is high grade (~97% pure).

Injection Operations

For the Raton Basin site in Colorado, a minimal length of pipeline will be added in order to deliver the CO_2 into the Entrada formation through a deep well. Blue Source LLC, a SWP partner, and Manzano LLC, the field operator, are completing and connecting a pipeline from the La Veta injection site to the Sheep Mountain pipeline. Upon completion of the deployment phase test, this pipeline will be used to transport the captured CO2 from the La Veta field to the Permian Basin enhanced oil recovery market. Figure 2 represents the planned general well design for injection operations.

For the Green River basin deployment, detailed injection operations will be determined based on final designation of the injection site.

Characterization Data

Because the Raton and Green River sites are in areas of active petroleum generation, the amount and quality of characterization data is fairly good.

Research Objectives:

SWP's overall goal is to validate the information and technology developed under the Characterization and Validation Phases relative to research and field activities, public outreach efforts, and regional characterization. Specific objectives include:

- Develop an overall methodology that optimizes engineering and planning for future commercial-scale sequestration projects.
- Conduct successful large-scale CO_2 injection projects targeted at the Entrada Formation.
- Achieve a more thorough understanding of the science, technology, regulatory framework, risk factors, and public opinion issues associated with large-scale injection operations.
- Validate monitoring, mitigation, and verification (MMV) activities; modeling, and equipment operations.

- Refine capacity estimates of the target formation using results of the test.

Summary of Modeling and MMV Efforts: (Use the table provided for MMV)

The project will require extensive monitoring and simulation to determine if the storage operations are effective in trapping the injected CO_2 for millennia. Vertical seismic profiling and microgravity methods will be particularly utilized, given their proven ability to resolve the size of the CO_2 plume. Monitoring, mitigation and verification (MMV) techniques that will be used include repeat 3D seismic surveys, pressure monitoring, groundwater chemistry monitoring, pressure and fluid sample monitoring from other locations, soil gas sampling, and other methods. A variety of “in house” and commercial/public simulation tools will be used, including GEM, TOUGH2, TOUGHREACT, FEHM, CO_2-PENS, COMSOL, THRUST3D, MRKEOS and SWEOS.

Table 1 summarizes the monitoring approaches planned for the SWP Phase III deployment program.

Table 1. Monitoring options in the planning stages of SWP’s Phase III deployment project.

Measurement technique	Measurement parameters	Application
Introduced and natural tracers	Travel time Partitioning of CO_2 into brine or oil Identification sources of CO_2	Tracing movement of CO_2 in the storage formation Quantifying solubility trapping Tracing leakage
Water composition	CO_2, HCO_3, CO_3^{2-} Major ions Trace elements Salinity	Quantifying solubility and mineral trapping Quantifying CO_2-water-rock interactions Detecting leakage into shallow groundwater aquifers
Subsurface pressure	Formation pressure Annulus pressure Groundwater aquifer pressure	Control of formation pressure below fracture gradient Wellbore and injection tubing condition Leakage out of the storage formation
Well logs	Brine salinity Sonic velocity CO_2 saturation	Tracking CO_2 movement in and above storage formation Tracking migration of brine into shallow aquifers Calibrating seismic velocities for 3D seismic surveys
Time-lapse 3D seismic imaging	P and S wave velocity Reflection horizons Seismic amplitude attenuation	Tracking CO_2 movement in and above storage formation
Vertical seismic profiling and crosswell seismic imaging	P and S wave velocity Reflection horizons Seismic amplitude attenuation	Detecting detailed distribution of CO_2 in the storage formation Detection leakage through faults and fractures
Passive seismic monitoring	Location, magnitude and source characteristics of seismic events	Development of microfractures in formation or caprock CO_2 migration pathways
Electrical and electromagnetic techniques	Formation conductivity Electromagnetic induction	Tracking movement of CO_2 in and above the storage formation Detecting migration of brine into shallow aquifers
Time-lapse gravity techniques	Density changes caused by fluid displacement	Detect CO_2 movement in or above storage formation CO_2 mass balance in the subsurface

Land surface deformation	Tilt Vertical and horizontal displacement using interferometry and GPS	Detect geomechanical effects on storage formation and caprock Locate CO_2 migration pathways
Visible and infrared imaging from satellite or planes	Hyperspectral imaging of land surface	Detect vegetative stress
CO_2 land surface flux monitoring using flux chambers or eddycovariance	CO_2 fluxes between the land surface and atmosphere atmosphere	Detect, locate and quantify CO_2 releases
Soil gas sampling	Soil gas composition Isotopic analysis of CO_2	Detect elevated levels of CO_2 Identify source of elevated soil gas CO_2 Evaluate ecosystem impacts

Accomplishments to Date:
Site characterization is under way, and general scoping calculations (using model simulations) are being carried Out to design monitoring surveys (Table 1).

Summarize Target Sink Storage Opportunities and Benefits to the Region:
SWP's Characterization and Validation Phase analyses determined that the region's point sources emit approximately 320 million tonnes (350 million U.S. tons) of CO_2 per year, which for 100 years (assuming no change in emissions rate) translates to 32 billion tonnes (35 billion U.S. tons) total storage capacity needed. SWP's Characterization and Validation Phase analyses provide an initial estimate of capacity of the Entrada saline reservoirs for just five selected basins in the Southwest region to exceed 18 billion tonnes (20 billion U.S. tons), well over the 50% criterion. During the Deployment Phase, SWP will continue to refine capacity estimates and evaluate injectivity and other critical factors relevant to regional storage goals.

Cost:

Total Field Project Cost:
$ 80,742,114

DOE Share: $ 64,895,992
80 %

Non-Doe Share: $ 15,846,122
20 %

Field Project Key Dates:

Baseline Completed: December, 2008

Drilling Operations Begin: October, 2008

Injection Operations Begin: December, 2008

MMV Events: December, 2008

Field Test Schedule and Milestones (Gantt Chart):
The generalized Gantt chart below provides the overall timeline for the SWP Phase III deployment program